Jeeva Anandan : Reality and Geometry in Quantum Theory : Oxford D.Phil Jan 1997

Queries & Comments

Introduction : ✓ p.7 · development of views of Wigner & Van Fraassen on role of symmetries.

Ch1: Laws, Symmetries, Geometry, & Operationalism:

p.11. ✓ para 3 line 4ff : operationalism determines the appropriate concepts for constructing laws, while symmetries determine the appropriate mathematical structure for the laws using these concepts, which have a conceptual character. — Wigner's unreasonable effectiveness of maths in the Natural sciences.

p.18 para 4 line 2, introduce complex structure

p.19. ✓ para 1, line 1 Numbers viewed as multiplicative & additive groups of transformations, but of what (numbers: cf. Dummett on p.16 para 2).

~~p.23 Bourbaki quote (maths concerned with relations between objects' — [illegible]~~:

p.24, ✓ para 2, last line — present philosophy tends to obliterate the distinction between objects & structures. — cf Bourbaki quote on p.23, para 4 — 'mathematics is concerned ~~with~~, not with objects, but relations between objects' — — but can structure be defined without objects — cf Russell, structuralist programme in phil. of maths. Also 'structure is a property of relation, not a relation'.

p.25 2nd para quote from Bridgman 'concepts defined in terms of operations' — .

p.29 line 1, para 1, Einstein goes beyond operationalism in obtaining the universal concept that the Lorentz group is an invariance group of Nature

pp

p.29 para 3 : defines operational universalism
— operational procedures + universal concept (abstracted)

p.30 para 1, last 4 lines : critique of Bridgman's plethora of concepts. — go for the underlying universal concept.
— continues in para 2, as well as of [illegible]

p.31 ~~near~~ para 1, mean K.E. is 3/2 or 5/2 kT for different gas but same, viz. 1/2 kT per degree of freedom.
Temperature is underlying universal concept.

p.32 para 1 Tolman formula. T is parameter in Boltzmann distribution (canonical ensemble)

p.33 para 1 — Newton's absolute time — critique of an operational defn — cf last 3 lines of quote

p.35 para 2, last 2 lines: space, time relate to translations "which relate physical entities"

p.36. para 2 line 2 ff : Minkowski space-time is absolute (independent of operational procedures)

par 3 Concept of S-T may be regarded as ontological .. This is particularly so when gravitation is incorporated — ?

p.37 para 1 lines 3,4. Entities defined in terms of coarse-grained observables — what about fine-grained entities — Discuss p.37 para 4, lines 4ff. Symmetries of laws can be used to construct a geometry à la Klein.

p.38. Weyl: transformation group is just as a premise as the point relations it relates (last line para)

p.39 P = group of symmetries of laws.
G -- " " geometry.
Then $G = P$ (eq 1-5) (Occam's razor)

p.40 para 1 Curie's principle: symmetry in cause → symmetry in effect but for asymmetries no.

para 3, last 5 lines..

p.41 end of para 1, violation of Curie's principle here statements 'symmetry breaking' — NO violations are apparent

3 [illegible]

Chandon Thesis – Typographical errors

[~~p.41, para 2, line 2 "it allows ----"~~
~~last line, 'most' → 'many'~~]

p.42 [illegible] → [illegible]. [illegible] due to [illegible] [illegible].

para 3 extension of Cayley's [illegible] to synchr. & asynchronous covers.

– relates to issue of whether time-evolution operator is 1:1 (i.e. invertible. so lots of [illegible] states [illegible] [illegible] [illegible])
– good discussion of Chaos in [illegible]. *

p.43 para 2. Two types of groupoids, general & universal (cf general unit groupoid [illegible] Frobenius / [illegible] classification).

p.44 introduces geodesic flow, Kähler metric & Fubini-Study metric.

p.50 para 2, agrees with Kant that arithmetical propositions are synthetic a priori (cp ~~of~~ drafts & [illegible] ?)

p.51 para 1 Every groupoid is a sub-group of 1:1 transformations — so Cayley's [illegible] is always [illegible].

para 2, last line: for classical/etc dynamics groupoid is not the group of 1:1 transformations (but a sub-group?)

p.52

p. 54 para 1, line): structures are artefacts of objects

para 3: Ghins claims that reality comes in degree, and is proportional to the size of the invariance group.

p. 55 para 1, last line, 'more real' confused with 'more true'?

p. 56 differential, topological & cardinality structure (i.e. frozen) more real than the metrical structure (end of para 1)

ch 2 Quantum Equivalence Principle & Quantum General Covariance.

p. 58 end of para 2, S-T is 4-dimensional 'ether'!

p. 59 para 2. geometrical reformulation of QT — Anandan's approach using quantum principles to guide gen's (i.e. we want to reconcile Q.T. & GR by this approach).

para 3: Define distance between states in H, analogous to distance between points in S-T (cf [illegible]?)
N.B. individual points of projective Hilbert space are real — can be observed using protective measurement
para 4: we need a quantum equivalence principle

p. 60 para 3: A. says distinction between active & passive transformations in hole argt. "is doubtful"

p. 60 para 4. quantum superposition of 2 geometries on wave function of a test particle would be described → S-T points have no invariant meaning. Hence ST (ether) should be eliminated to incorporate quantum diffeomorphisms into Q. Grav. → quantum general covariance.

p. 61 para 1, line 4 ∃ neighborhood U(P) where trajectories satisfy $\frac{d^2x^\mu}{d\tau^2} = 0$ (to 1st order ...?)

p. 62 para 1, line 4 cf. def^n 1st order infinitesimal neighborhood of p. $U_\varepsilon(p)$
para 3 – geodesics define projective structure. null lines define conformal ".

p. 63 para. 3, line 2 ref. to torsion
affine connection + conformal structure → Weyl structure (para 4)

p. 64 no observed evidence for change in length under transport (Weyl geometry), para 3.

p. 67. formulates in (2-3) the quantum weak equivalence [illegible]

p. 68 para 2 : "appropriate conditions made mathematically precise": $U_\varepsilon(p)$ → tangent space at p, treated as an affine space. ? Does this work for wave packets? [illegible]

p. 73 R = 0 (Eq. 2-10 on p. 72) has as orbit an infinite no of Minkowski metrics (end of para 1.) NO (?) these metrics are all isometric, so 3 is no new notion of dragging ?

p.74 para 2: defines active & passive transformations

p.75 para 2 continues defn of active Poincaré transformation.

p.76 para 4 distinguishes fixed & dynamical objects (fixed = absolute?)

p.77 para 2, passive diffeomorphisms defines passive C.G. (local [illegible]?)

end of para 2 active C.G. is said to correspond to local gauge symmetries in gauge theories (but of gl(4,R) as gauge group?)

p.78 para 2, line 1 Einstein [illegible] in hole argt. may be regarded as different representations of the same objective physical geometry

so para 3, last line: active & passive diffeo's are both a 'new choice of labels'.

para 4 real structure is embedded in an eq. set of mathematical copies — cf Wahlfreiheit of gauge fields. But A. rejects this view on operational grounds.

para 5, last line In diff. geom. there is no distinction between active & passive transformations — I DON'T AGREE.

p.81 line 2 Ontology = Geom. = Physics

p.83 Para 1 argues that in quantum gravity, space-time points have no invariant meaning under quantum effects p.84 para 2 line 1 – Is it the quantum uncertainty in the grav.-field that makes points of S-T meaningless.

Ch 3 Classical & Quantum Space-time.

p.85 para 2, lines 1, 2. S-T ontology is a world of being not becoming – (too quick – cf Stein's etc.).
para 2, line 6: did Newton assumed c was ∞? (Römer's data?)

p.87 para 2 7 lines from end A. seems to assume that non-Newtonian S-T has a relative (non-absolute) (cf rel. to Galilei boosts – in penultimate line).

para 3 existence of boost symmetries dictates change in ontology from space, time to S-T.
I DISAGREE.

p.93 end of para 1. Refs 3, 4 seem wrong.
p.96 last line, para 1, Refs 5, 4 seem wrong.

p.97 Sec. 3.4. Fermionic nature of S-T.
p.101 para 2. neat introduction of supersymmetry in its notation.

Ch 4 Space-Time Geometry, Dynamical Completeness and a New Criterion of Reality

p.104 para 2 defines Action-Reaction Principle.
a theory is dynamically complete if (and only if?) all entities postulated satisfy [illegible] A-R Principle

para 2

p. 105 (?) 'AR is Machian, but combined with locality it is 'anti-Machian. GR is Machian in sense that s-t is dynamical, but not in respect of AR principle.'

cf Lense-Thirring and of rotating ring

Sect. 4.2. : bottom of p. 105. Does geometric phase satisfy AR principle?

p. 106 para 1 : defs geometric phase - end of para 1, geometry of $\mathcal{H}$ (projective Hilbert space) should become dynamical, so as to satisfy A-R.

para 2 lines 1. use quantum probes, not classical probes

p. 107 describes core part. (phase shift in a gravitational field)

p. 109 para 3, last line: ref. to Tolman

p. 110 para 2, line 2, eq (6) is wrong?
para 3, line 3, eq (14) is wrong

p. 111 para 2 last 2 lines: criterion of reality in terms of satisfying the A-R principle.
para 3, last line, A-R supports view that superposition of a single particle is real (in addition to argument from protective measurements)

p. 112 para 2, last line, refs 15-17 wrong!

p. 113 para 4. Reality of particle from A-R in the Bohm theory p.114 para 3, line 1. 'Bohm theory suffers from 2 defects' 1) violates A-R principle

p.115 2) double role of ψ in Bohm-theory.
para 2, last line - this is explained in Dürr et al — [illegible]?

Ch5: Towards a Quantum Geometry

p.116 para 1 — what was Hamilton's motivation for his formulation of classical mechanics?
para 2, line 2, ref. to Guillemin & Sternberg (not primary historical source)

p.122 para 2, symplectic form is general, not universal, last 3 lines,
– for a universal geometry we need a subject into symplectic mech.

p.125 para 3, 4 lines from end: Hamilton found canonical geom. (symplectic) & generalised offers) classical problems.

p128 para 1, line 2, protective measurements enlarge what is said in QM. All values of $\langle \psi | A | \psi \rangle$ can be measured, not just the eigenvalues (of A)
para 2. ~~and of para~~, ref. to work of Heslot (1985) [80]
a classical quantum analogue of Poisson bracket.

p.132 para 1, line 1: refers to uncertainty in determination of S-T points of measurement of S-T distances beyond the Planck length.

MR

p.133 para ~~3~~ 4: 4 groups of symmetries in dynamics
G_1 = covariance transformations (i.e. symplectic transf)
G_2 = diffeomorphisms of phase space. (i.e. canonical symmetries)
G_3 = maps of solns of H. Eqn onto other solns of Hamilton eqs.
G_4 = invariance group of Hamiltonian

p.134 (5.1) para 1, line 3 says: ~~[illegible]~~
$G_1 \supset G_2 \supset G_3 \supset C_4$.

p.135 para 2, last sentence: "There is a perfect symmetry between active & passive transformations because of Leibniz's [illegible] of identity of indiscernibles.

p.138 para 1, quantum gen. ~~bears~~ ~~same~~ relation ($\hbar \to 0$) to S–T as does Hilbert space to phase space.

p.141 Para 3, line 2 ff. All observables are elements of a universal symmetry group.

p.142 para 1 line 1 – symmetry plays a different role, so overcoming defects of choosing the facts, in the Erlanger Program(?) (ref. to M B in footnote (?))

p.143 para 2 discusses Van Fraassen's views on symmetry — does not believe in a symmetry ontology

para 3, last line — symmetries of laws are pretty much the same at both levels (appearance & fundamental).

p.144 para 1, laws ~~are contingent~~ may change at deeper levels, but symmetries persist (more permanent existence)?. Replace laws by symmetry — This may be the law which ends all laws?